

NEW SPECIES OF *SPLINDIDOFILARIA* AND *CHANDLERELLA*
(FILARIOIDEA: NEMATODA), WITH KEYS TO THE SPECIES,
FROM THE BAND-TAILED PIGEON
(*COLUMBA FASCIATA FASCIATA*)¹
IN THE ROCKY MOUNTAIN REGION

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ABSTRACT.— One male each of *Splendidofilaria columbensis* n. sp. and *S. hiblieri* n. sp. was found in the subcutaneous fascia of the thighs of a single band-tailed pigeon. The relationship of female worms could not be correlated with the males. *Chandlerella robinsoni* n. sp. was recovered from the blood vessels of the liver and the fascia of the thighs of six birds. Keys to the males of the species of both genera, together with drawings of the spicules of each species, when available, are included.

Published reports of helminths from band-tailed pigeons are meager. Neff (1947) reported 12 "flatworms" in the abdominal cavity of a band-tailed pigeon collected in Colorado, while Smith (1968), working in California, mentions finding a specimen of *Ascaridia columbae* in the connective tissue of one bird, and nematodes, which were not identified, in another.

During the period from June 1969 through September 1974, 674 band-tailed pigeons were collected in Colorado (645), New Mexico (23), and Mexico (6) and examined for helminth parasites. Specimens of Splendidofilariinae Chabaud and Choquet, 1953, were recovered from 11 birds.

Five birds harbored specimens of *Splendidofilaria* Skrjabin, 1923, in the subcutaneous fascia between the thighs and the body. Six different birds were parasitized by specimens of *Chandlerella* Yorke and Maplestone, 1926, in the blood vessels of the liver and in the subcutaneous fascia also between the thighs and the body. In each instance, only a few parasites were found in individual birds.

Worms of the genus *Splendidofilaria* consisted of two males from the same pigeon, plus females from this and other birds. The males have spicular conformation and size, together with the number and arrangement of caudal papillae, and length of tails so different from each other and from those of described species that we believe they constitute two new species.

While the females could not be correlated with the two different males, there

appear to be two and possibly three different kinds, based on the shape and length of the vagina and the size and general morphology of the microfilariae.

The new species, based on a single male specimen each, are named *Splendidofilaria columbensis* and *S. hiblieri*.

Specimens of the genus *Chandlerella* consisted of several males similar in morphology and a larger number of females. This species is named *C. robinsoni*.

With so few birds infected in such a large sample, it is the opinion of the authors that the limited information should be presented so that other parasitologists may be aware of the results of this investigation. Moreover, future studies on band-tailed pigeons or other Columbiformes may bring to light additional information to support or to suppress the validity of these newly described species.

Gibson (1967) and Koch and Huizinga (1971) described *Splendidofilaria pectoralis* and *S. passerina*, respectively, subsequent to the appearance of Sonin's (1966) monograph. Gibson (1968) redescribed *S. papillocerca* (Lubimov, 1946).

Keys based on published descriptions and figures of males of the species of *Splendidofilaria* and *Chandlerella* considered by Anderson and Freeman (1969) as valid for these two genera are presented as an aid to other workers in differentiating them.

MATERIALS AND METHODS

Birds collected in Colorado and New Mexico were tagged, promptly frozen, and kept until examined within four

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months, a procedure that degraded the morphological quality of the specimens. Birds taken in Mexico were examined within an hour after being collected. All worms were preserved in 70 percent ethyl alcohol containing glycerine. They were cleared by allowing the alcohol to evaporate in an open container kept at room temperature, thus slowly bringing them into pure glycerine.

Microfilariae were dissected from the anterior end of the vagina of adult females already cleared in glycerine. The drawings were made with the aid of a camera lucida from optical sections of unstained larvae under oil immersion of a phase contrast microscope. All measurements are in microns except when otherwise indicated.

RESULTS

Splendidofilaria columbensis, n. sp.

Figs. 1, 2.

GENERAL: Filarioidea, Onchocercidae, Splendidofilariinae Chabaud and Choquet, 1953. Slender worms with both ends of body slightly attenuated. Buccal capsule absent, oral opening minute. *En face* preparation not made from single specimen available, amphids and cephalic papillae not seen in lateral view. Esophagus long, narrow, presence of anterior muscular portion doubtful. Intestine broad, mostly straight, filled with granular-like material. Caudal extremity of body bears one pair of minute, nearly terminal protuberances. Minute phasmids near posterior extremity of body. Cuticle thin, with very fine transverse striations and small, mostly circular bosses except at extremities of body. Excretory pore and deirids could not be located.

MALE: Body length 22 mm; maximum width 180. Nerve ring 45 from anterior extremity. Esophagus slender, length 710. Tail about equal in diameter throughout its length, 110 long. One pair preanal papillae located a distance anterior to cloaca about equal to length of spicules. Three pairs postanal papillae distributed about equidistant from each other along tail. Spicules dissimilar, each with well defined head separated from body by a constriction, truncated distally; right spicule 46 long, body broad, slightly expanded medially, left spicule 49 long,

narrower than right, dorsal side with notch near union of distal and middle thirds of length.

FEMALE AND MICROFILARAE: See below.

HOST: Band-tailed pigeon, *Columba fasciata fasciata* (Say)

LOCATION: Fascia of thighs

LOCALITY: Colorado, U.S.A.

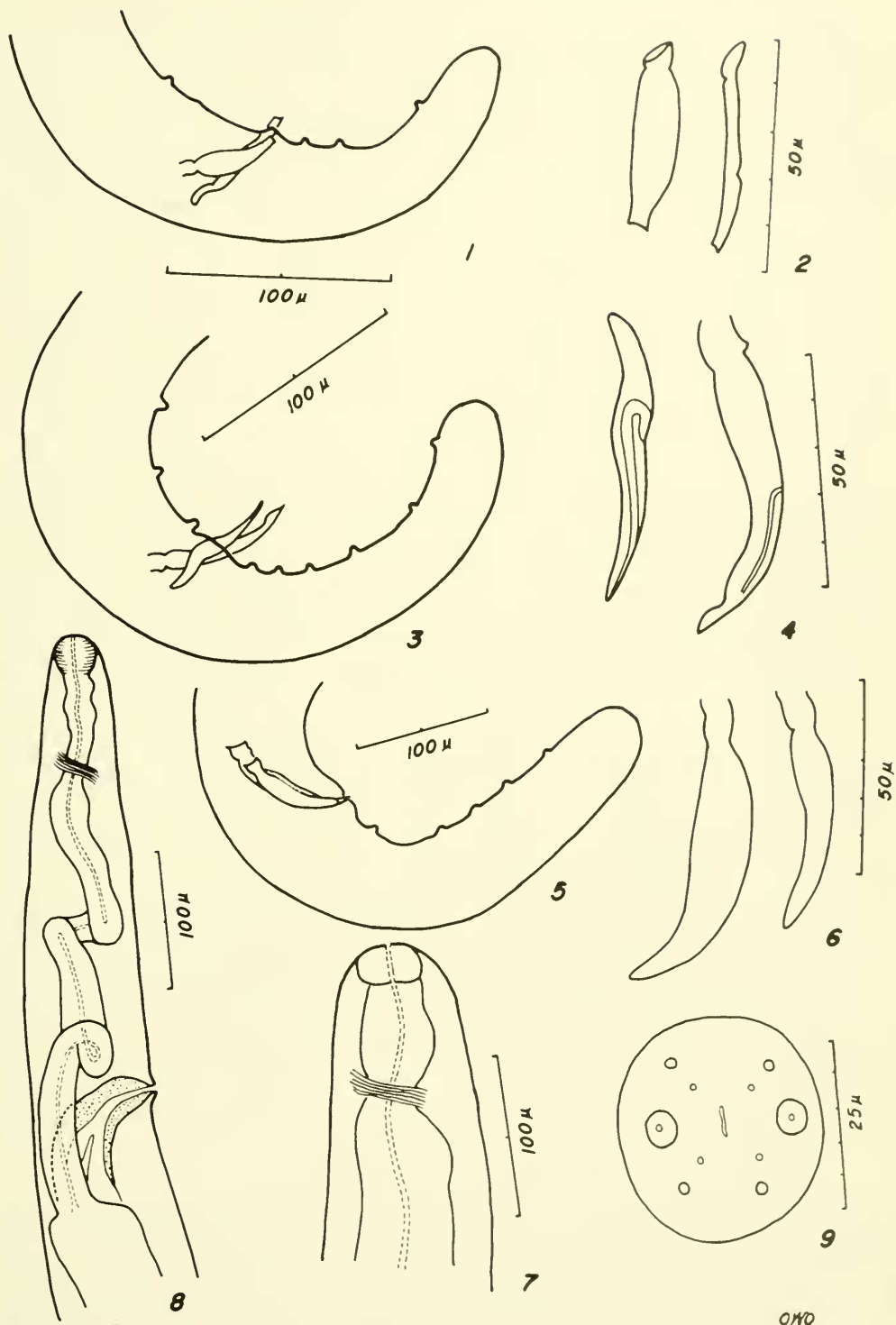
Holotype (male), USNM Helm. Coll. No. 73225.

DISCUSSION: Of the bosselated species of *Splendidofilaria*, *S. columbensis* resembles *S. hiberni* n. sp. and *S. gedoelsti* Travassos, 1926, in having a tail 110 or more in length, whereas the other species in this group have a tail less than 100 long. Of these three species having long tails, *S. columbensis* and *S. gedoelsti* resemble each other in having one pair each of preanal papillae but differ in that *S. columbensis* has no peri- and three pairs of postanal papillae, whereas *S. gedoelsti* has three pairs of peri- and four pairs of postanal papillae. The spicules of these three species differ markedly in shape (cf. Figs. 1, 2; 3, 4; 18). *S. columbensis* (Fig. 1) and *S. gedoelsti* differ from *S. hiberni*, which has three pairs of pre- and six pairs of post- but no perianal papillae (Fig. 3); the spicules differ markedly in shape (Figs. 2, 4). In addition to the above characteristics, these three species, together with *S. picacardina* Hibler, 1964 (which has a short tail), are much longer than all other species of the bosselated group.

Splendidofilaria hiberni, n. sp.

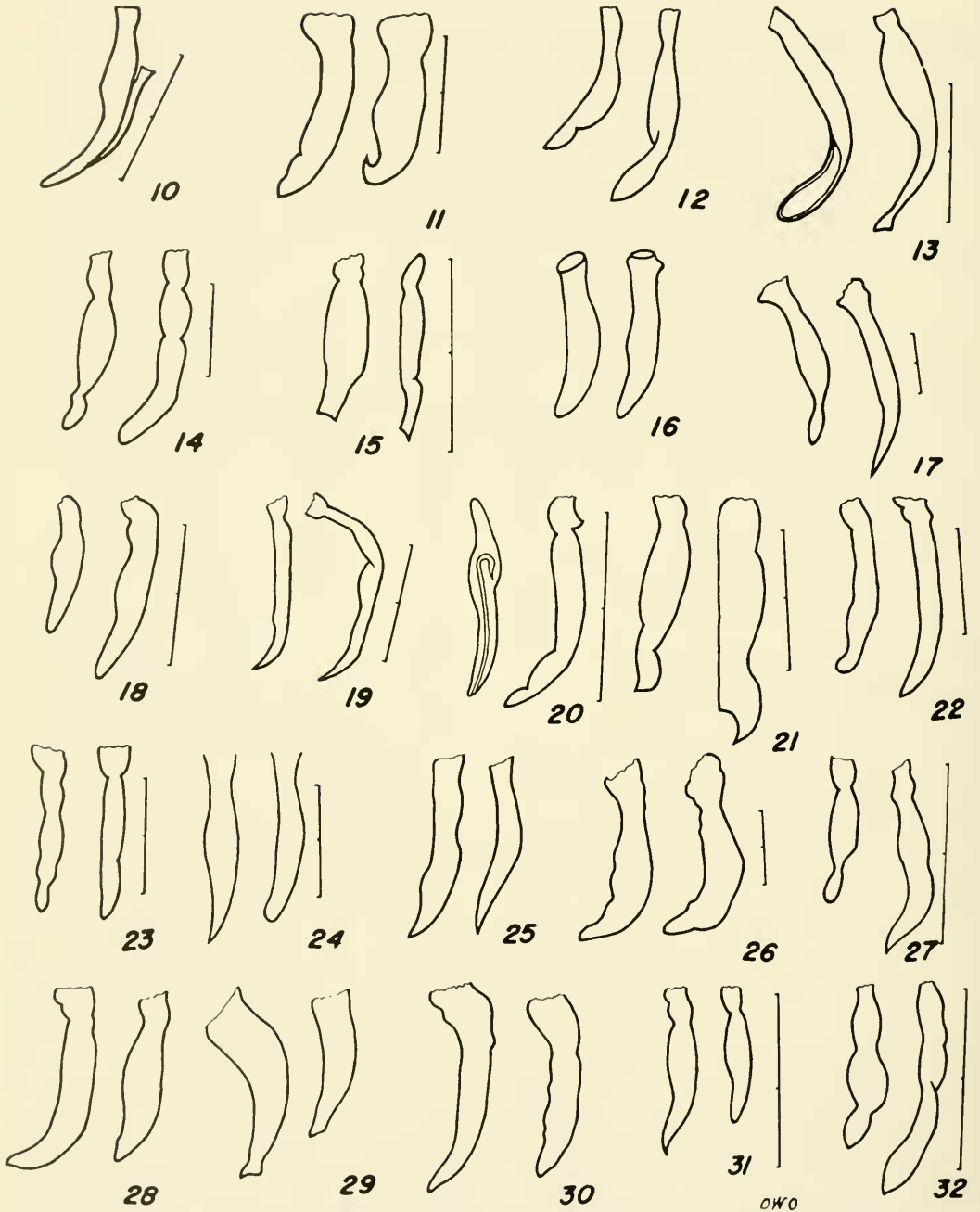
Figs. 3, 4.

GENERAL: Filarioidea, Onchocercidae, Splendidofilariinae Chabaud and Choquet, 1953. Slender bodies with extremities slightly attenuated. Buccal capsule lacking, oral opening minute. Amphids and cephalic papillae not seen in whole mount as no *en face* preparation made from single specimen available. Esophagus long, presence of anterior muscular portion doubtful. Intestine broad, filled with granular material. Caudal extremity with pair of small fleshy protuberances. Phasmids not seen. Cuticle thin, smooth, with delicate transverse striations, circular bosses scattered over body, particularly behind middle, absent from ends. Excretory pore and deirids not seen.



Figs. 1-4. *Splendidofilaria* spp.: 1, Tail of male *columbensis* n. sp.; 2, spicules of *columbensis*; 3, tail of male *hibleri* n. sp.; 4, spicules of *hibleri*.

Figs. 5-9. *Chandlerella* spp.: 5, Tail of male *robinsoni* n. sp.; 6, spicules of *robinsoni*; 7, anterior end of male *robinsoni*; 8, anterior end of female *robinsoni*; 9, en face view of *robinsoni*.



Figs. 16-32. *Splendidofilaria* spp.: Spicules are shown in lateral view. Right spicule is the one on the left of each pair except in cases where only a single spicule is depicted. All scales where available are adjusted to 50 μ . Figures marked with an asterisk were adapted from Sonin (1966), the others from original publications. Fig. 10, *algonquiensis* (Anderson, 1955); 11, *böhmi* (Supperer, 1958); 12, *brevispiculum* Singh, 1949; 13, *californiense* (Wehr and Herman, 1956; 14, *caperata* Hibler, 1964; 15, *columbensis*; 16, *falconis* Sonin, 1966; 17, *fallisense* (Anderson, 1954); 18, *gedoelsti* Travassos, 1926*; 19, *gretillati* (Chabaud, Anderson, and Brygoo, 1959); 20, *hibleri*; 21, *kashmirensis* Amir and Ali, 1960; 22, *maris* (Leiper, 1909; 23, *papilloecera* (Lubimov, 1946); 24, *passerina* Koch and Huizinga, 1971; 25, *pawlowskyi* Skrjabin, 1923; 26, *pectoralis* Gibson, 1967; 27, *picacardina* Hibler, 1964; 28, *rotundicephala* (Oschmarin, 1950); 29, *singhi* Sultana, 1962; 30, *tuvensis* (Spassky and Sonin, 1957); 31, *verrucosa* Oschmarin, 1950; 32, *wehri* Anderson, 1961.

MALE: Body length 22 mm, maximum width 191, nerve ring not visible. Esophagus slender, 450 long. Tail 137 long. Caudal extremity of body blunt. Three pairs of pre- and six pairs of postanal papillae evenly distributed along tail. No perianal papillae. Spicules subequal and dissimilar, right 61 long, with distinct bend at union of anterior and middle thirds, distal end sharply pointed; left 70 long, with entire body curved, tapering to narrower end that bends sharply ventrad, forming a pointed spatulate end with expansion toward ventral side.

Named for Dr. Charles P. Hibler.

FEMALE AND MICROFILARIAE: See below.

HOST: Band-tailed pigeon, *Columba fasciata fasciata* (Say)

LOCATION: Fascia of thighs

LOCALITY: Colorado, U.S.A.

Holotype (male), USNM Helm. Coll. No. 73226.

Females and microfilariae: Since the females could not be correlated with the two species of males, they and their microfilariae are considered as a group. Differences in the configuration of the vaginae and size of the adult females and the morphology of their microfilariae suggest possibly three separate kinds of worms. Tails of the adults are similar (Figs. 58, 61). A sheath is evident in specimens of some microfilariae from each group of females.

In one group of females, the vagina forms a complicated double set of loops (Figs. 56, 57). The distance from the anterior end of the body to the vulva is 392, and from the latter to the uterus is 466. The length of the vagina is greater, since its coils are not included in the measurement. The body is 12 mm long. Microfilariae have a finely striated cuticle and the body terminates as a long, slender, pointed tail in which nuclei extend single

file to the tip; only small nuclei appear in the anterior extremity (Fig. 59). The microfilariae measure 119-149 (average 139) in length and 2.14-4.3 (average 3.2) in diameter.

A second type of female is represented by a long, slender vagina with a large, single loop open on one side and much farther caudal (Fig. 60) than the loops in the preceding group. The vulva is 306 from the anterior end of the body and the distance from the vulva to the uterus is 2.44 mm (the vulva is longer due to the loop). The body is 44 mm long. Microfilariae are thick bodied, smooth, and have a somewhat blunt tail without nuclei; nuclei in the anterior end are small (Fig. 62). The larvae are 118-154 (average 129) long by 5.3 in diameter.

A third type of female has a long, narrow, straight vagina (Fig. 63) about 1.6 mm in length. The vulva is 354 from the anterior end of the body. The body is 17 mm long. The smooth, slender microfilariae have a long pointed tail in which the nuclei extend single file to the tip. A large nuclear mass appears at the anterior extremity (Fig. 64). The body is 128-152 (average 139) long and 4.3 in diameter.

It was not possible to identify with certainty the nerve ring, excretory cell, inner body, R-cells, and anal cell in these glycerine-cleared microfilariae because they would not stain.

DISCUSSION: *S. hiblieri* is one of the four large bosselated species, together with *S. columbensis*, *S. gedoelsti*, and *S. picardina*, as pointed out in the previous discussion. It differs from the other three species in the distinctive shape of the spicules (Figs. 2, 4, 18, 27) and in having three pairs of pre- and six pairs of postanal papillae (Fig. 3). None of the other species has so many papillae arranged in this manner. There are no perianal papillae.

Key to the species of *Splendidofilaria*

- | | |
|---|--|
| 1. Cuticle with bosses | 2 |
| Cuticle without bosses | 12 |
| 2(1). Longer spicule about equal to or greater in length than tail | 3 |
| Longer spicule distinctly shorter than tail | 9 |
| 3(2). No caudal papillae, spicules straight, with well-defined heads, right 95 long with narrow rounded distal end, left 130 long (Fig. 23) | <i>S. papillocerca</i> (Lubimov, 1946) |

- Caudal papillae present 4
- 4(3). Perianal papillae present 5
 Perianal papillae absent 6
- .5(4). Two pairs peri- and three pairs postanal papillae; right spicule 37-44 long with pronounced mid-dorsal expansion, left 54-58, middle and posterior parts broad and about equal in length; tail 51-60 long (Fig. 12) *S. brevispiculum* Singh, 1949
 Perianal papillae only present, two on right side and three on left, right spicule 57 long, body divided into three distinct expanded parts by constrictions, left 65 long, with two major divisions about equal in length; tail 63 long (Fig. 32).....
 *S. wehri* Anderson, 1961
- 6(4). One pair postanal papillae 7
 Two pairs postanal papillae 8
- 7(6). Spicules with distinct head, robust, left 95-120 long and relatively straight on ventral side except at tip, right 78-82, proximal and distal ends of both set off by dorsal notches, tips enlarged, rounded on dorsal side and ending in a point; tail 95 long (Fig. 21) *S. kashmirensis* Amir and Ali, 1960
 Spicules with broad distal end without constrictions and gradually tapering to obliquely truncated distal ends (described as pointed ends), right 70 long, left 50; tail 48 long (Fig. 29)
 *S. singhi* Sultana, 1962
- 8(6). One pair preanal papillae, spicules roughly similar in shape, without well-defined head, each with pointed distal end, right somewhat more robust and 77 long, left narrower and 68 long; tail 57 long (Fig. 25) *S. pawlowskyi* Skrjabin, 1923
 Two pairs preanal papillae; spicules with well-defined head, markedly dissimilar in shape, right 42-50 long, with middle portion largest and distinctly expanded dorsally and ventrally, distal end narrow with rounded tip, left 50-65 long, middle and distal parts about equal in length, latter pointed; tail 62-89 long (Fig. 27) *S. picacardina* Hibler, 1964
- 9(2). No pre- but two pairs postanal papillae (one pair very indistinct), spicules somewhat similar in shape, with distinct head, right 45 long and sharply pointed, left 40 long and rounded distally; tail 60 long (Fig. 31) *S. verrucosa* Oschmariu, 1950
 Preanal papillae present 10
- 10(9). Three pairs pre- and six pairs postanal papillae; spicules dissimilar in shape, left 70 long, with distinct head, middle part long, straight, distal part sharply bent ventrad, not pointed but divided by ventral notch, right 61 long, no distinct enlarged head, anterior and posterior parts narrower than middle, distal end pointed; tail 137 long (Figs. 3, 4) *S. hiblieri* n. sp.
 One pair preanal papillae 11
- 11(11). One pair pre-, three pairs peri-, and four pairs postanal papillae; spicules with more or less evenly arched dorsal surface and mid-ventral expansion, distal portion narrow and with rounded tip, left 71 long, right 63 long, heads not distinctly set off by constrictions; tail 120 long (Fig. 18) = = *S. geddoelsti* Travassos, 1926
 One pair pre-, no peri-, and four pairs postanal papillae; spicules with heads distinctly set off by constriction, distal ends truncate, right 46 long, broad in basal two-thirds, narrow in distal

- third, left 49 long, narrow throughout, notch on dorsal side separating middle and distal thirds; tail 110 long (Figs. 1, 2)
 *S. columbensis* n. sp.
- 12(1). Longer spicule over 100 in length 13
 Longer spicule less than 100 in length 16
- 13(12). Left spicule with hook-shaped distal end, 102-105 long, right with tip straight, somewhat pointed, 86-110 long; two pairs preanal papillae with one pair near anus and two pairs postanal papillae with one pair near anus and other near end of body; tail about 75 long (Fig. 11) *S. böhmi* Supperer, 1958
 Spicules without distal hook 14
- 14(13). No caudal papillae; spicules with middle part expanded in lateral view, tips rounded, right 122-140 long, left 131-145 long; tail 92-100 long (Fig. 26) *S. pectoralis* Gibson, 1967
 Caudal papillae present 15
- 15(14). Three pairs pre-, two pairs peri-, and two pairs postanal papillae; spicules dissimilar, right 140-150 long, tapering to a point, left 110-120 long, sides more or less parallel, blunt; tail 60-80 long (Fig. 30) *S. tuvensis* Spassky and Sonin, 1957
 No pre-, two to three pairs postanal papillae (sometimes one pair perianal papillae); spicules fairly similar and more or less simple, blunt apically, right 109-136 long, left 97-117; tail 160 long (Fig. 16) *S. falconis* (Sonin, 1966)
- 16(12). Tail shorter than long spicule 17
 Tail about equal to or greater in length than that of long spicule 20
- 17(16). One pair caudal papillae only, located at tip of tail; right spicule 80-90 long, sides parallel, tip rounded and slightly expanded, left 60-80 long with middle part expanded and tip pointed; tail 40-55 long (Fig. 28) *S. rotundicephala* Oschmarin, 1950
 More than one pair of caudal papillae 18
- 18(17). Two pairs of postanal papillae only, in posterior half of tail; right spicule narrow, body straight, tip curved ventrally and pointed, 62 long, left strongly arc-shaped, 78 long; tail about 65 long (Fig. 19) .. *S. gretilati* Chabaud, Anderson, and Brygoo, 1959
 Both pre- and postanal papillae present 19
- 19(18). Two to three pairs each of pre- and postanal papillae; right spicule small, narrow, pointed, 58 long, left large, proximal end and median portions expanded and separated by broad constriction, distal third narrower, 80 long; tail 42 long (Fig. 10)
 *S. algonquinensis* (Anderson, 1955)
 One pair pre- and two pairs postanal papillae (one near anus [?] and one near tip of tail); spicules with basal end slightly enlarged, right blunt distally, left pointed, both about 90 long; tail 50 long (Fig. 22) *S. mavis* (Leiper, 1909)
- 20(16). One pair each of pre- and postanal papillae; right spicule equal in width throughout, tip broadly rounded, 68-78 long, left with thick basal half of body, distal half slender and with expanded truncated tip, 57-71 long; tail 88 long (Fig. 13)
 *S. californiensis* (Wehr and Herman, 1956)
 More than one pair each of pre- and postanal papillae (sometimes only one pair of preanal papillae) 21

- 21(20). Cuticle with coarse annular wrinkles; one pair pre-, two pairs peri-, and two to three pairs postanal papillae; left spicule 73-81 long, its body divided into three parts with distal section longest, tip rounded, right 54-66 long with middle portion expanded and longest, narrow tip spatulate; tail 77-85 long (Fig. 14) *S. caperata* Hibler, 1964
 Cuticle without annular wrinkles 22
- 22(21). Left spicule 79-92 long, sides of basal two-thirds more or less parallel, distal third tapers to a point, right 53-76 long, with thickened middle portion, narrows distally to form a spatulate-like tip; three pairs pre- and postanal papillae, possibly one pair small papillae on anterior margin of anus, no perianal papillae; tail 58-79 long, without terminal protuberances (Fig. 17)
 *S. fallisensis* (Anderson, 1954)
- Head of spicules separated from body by a broad, shallow constriction; left 52-85 long, terminating in a point, right 45-85 long, with blunt, almost truncate tip; one to two pairs pre-, one pair peri-, and two to four pairs postanal papillae; tail 45-113 long, with two terminal protuberances (Fig. 24)
 *S. passerina* Koch and Huizinga, 1971

Chandlerella robinsoni, n. sp.

Figs. 5-9, 65.

GENERAL: Filarioidea, Onchocercidae, Splendidofilariinae Chabaud and Choquet, 1953. Slender worms with thin, smooth cuticle. Cephalic extremity with four submedian papillae and two lateral amphids. Buccal capsule absent. Excretory pore not seen. Esophagus externally divided with anterior extremity of muscular portion expanded into a bulb-like enlargement separated from remainder by a constriction. Junction of glandular portion of esophagus and broad intestine distinct.

MALE: Four specimens. Body length 8.0-15.5 (12.6) mm, width 204-215 (211). Nerve ring 106-146 (139) from anterior end of body. Muscular esophagus 109-233 (168) long, glandular esophagus 792-838 (810). Anus 154-231 (209) from posterior extremity of body. Five pairs of postanal papillae rather evenly distributed along tail. Spicules subequal, similar in shape, with narrow, deep, basal constriction, slightly and evenly curved ventrally, gradually taper to a point, right 81-97 (85) long, left 55-75 (65), maximum width 11-13.

FEMALE: Body length 17-24 mm, maximum width 276-339. Nerve ring 168-200 from anterior extremity of body. Muscular portion of esophagus 186-226 long, glandular portion 481-817 with bends. Vulva 478-678 from anterior end of body; vagina short, being 160-165 long in speci-

mens where clearly visible. Uteri didelphic and opisthodelphic. Anus 372 from posterior end of body in only specimen where seen.

MICROFILARIA: Body 177 to 198 (181) long and 4.3 in diameter. Fairly constant in diameter except for the tail, which is only slightly narrowed and which has a large globular nucleus at the tip. Somewhat enlarged and elongated nuclear masses appear laterally at the anterior end. Cuticle smooth, visible sheath on some individuals. Nerve ring, excretory cell, inner body, R-cells, and anal cell could not be identified in unstained glycerine-cleared larvae (Fig. 65).

Named for Dr. Edwin J. Robinson, Jr. (1971), who has done much to elucidate the development of *C. quisquali* in ceratopogonid gnats.

HOST: *Columba fasciata fasciata* (Say)

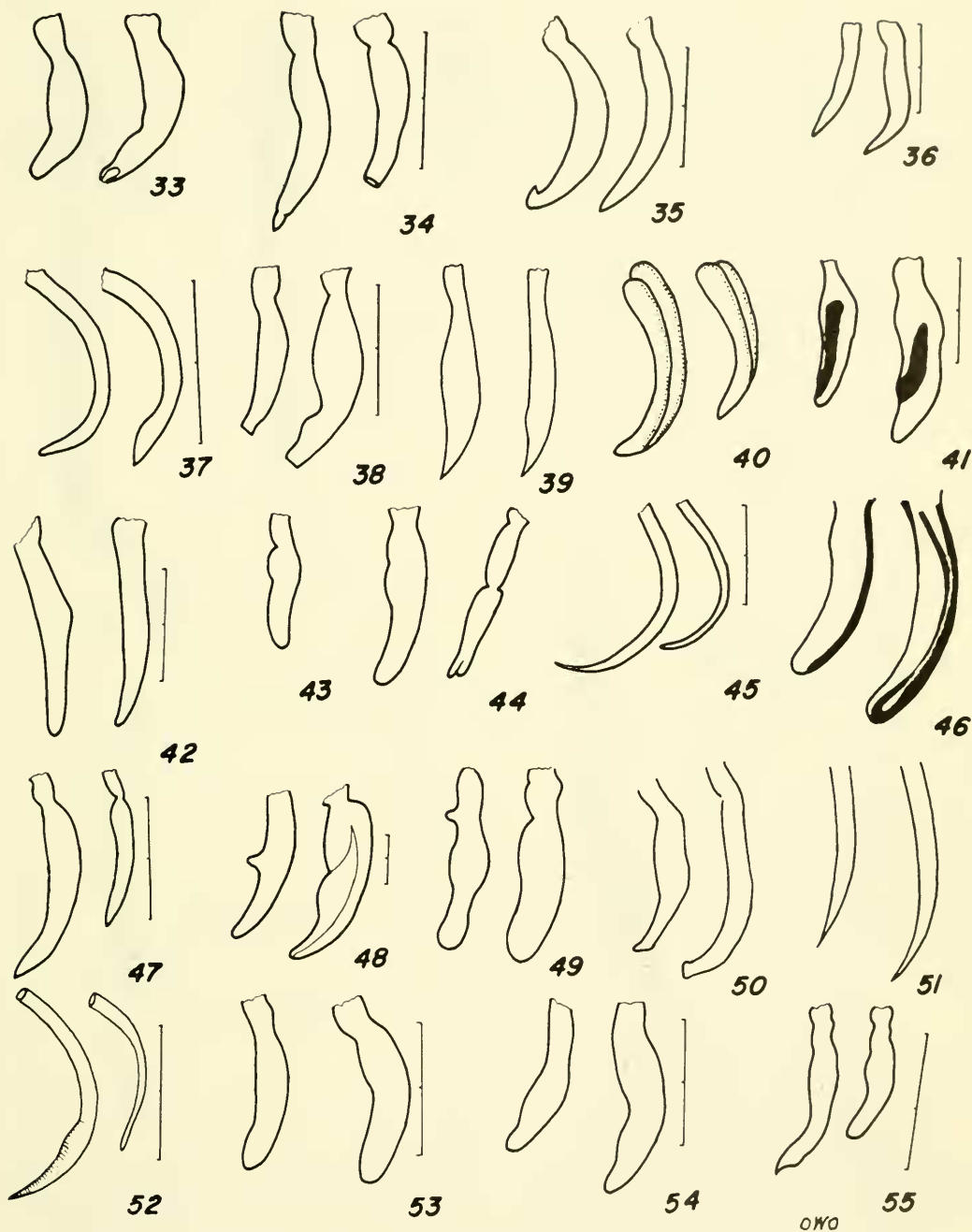
HABITAT: Subcutaneous tissue of thighs

LOCALITY: Colorado, U.S.A.

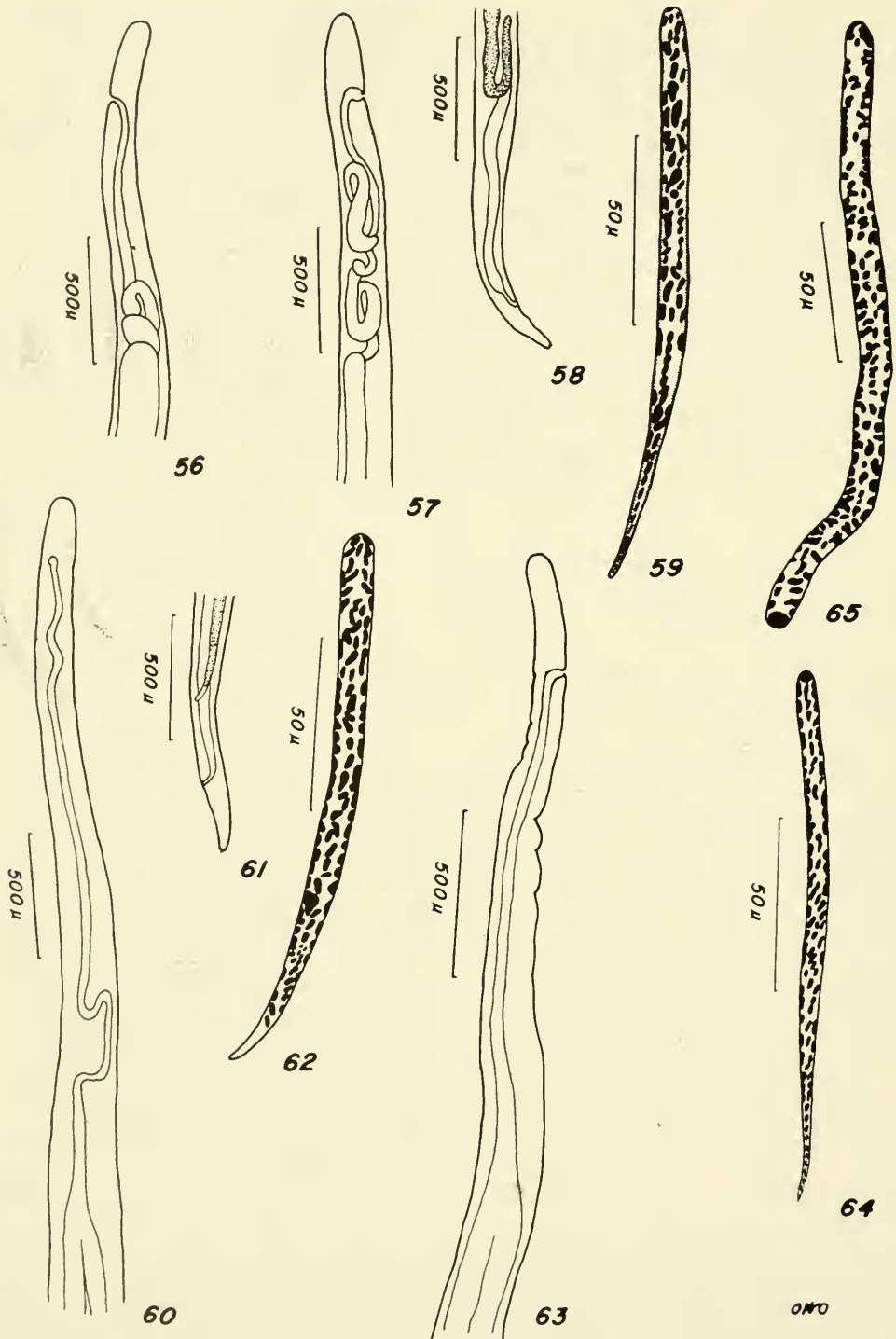
Holotype and allotype (males and females), USNM Helm. Coll. No. 73227.

Paratype (*en face* mount), 73228.

DISCUSSION: *C. chitwoodae* Anderson, 1961; *C. petrowi* (Tschertkow, 1946); *C. skriabini* Petrov and Tschertkow, 1947; and *C. robinsoni* resemble each other and differ from all other species in the genus in having the anterior end of the mus-



Figs. 33-55. *Chandlerella* spp.: Spicules are shown in lateral aspect. Right spicule appears on left of each pair. All scales of measurement where available are adjusted to 50 μ . Figures marked with an asterisk were adapted from Sonin (1966), the others from original publications. Fig. 33, *alii* Sultana, 1962; 34, *apusi* Sonin, 1963*; 35, *bosei* (Chandler, 1924); 36, *braziliensis* Yeh, 1957; 37, *chitwoodae* Anderson, 1961; 38, *columbae* (Sonin, 1966); 39, *columbigallinae* (Augustine, 1937); 40, *flexivaginalis* (Jones, 1961); 41, *hawkingi* Chatterjee, Sen, and Bhattacharya, 1965; 42, *himalayensis* Sultana, 1962; 43, *longicaudata* (Sonin, 1966); 44, *periarterialis* (Cabellero, 1948)*; 45, *petrowi* (Tschertkow, 1946)*; 46, *quiscali* (von Linstow, 1904) (from Robinson, pers. comm.); 47, *robinsoni*; 48, *sinensis* Li, 1933; 49, *singhi* Ali, 1956; 50, *skryabini* (Petrov and Tschertkow, 1947)*; 51, *stantchinskyi* Gilbert., 1932*; 52, *striatospicula* Hibler, 1964; 53, *sultana* Sonin, 1966; 54, *thapari* Rasheed, 1960; 55, *travassosi* (Koroliowa, 1926)*.



Figs. 56-64. *Splendidofilaria* spp.: 56-57, *S.* sp. showing variations in double loop of vagina; 58, *S.* sp., tail of female in Fig. 57; 59, microfilaria of *S.* sp. in Figs. 56-57; 60, *S.* sp., vagina with open bend; 61, *S.* sp., tail of female in Fig. 60; 62, microfilaria of *S.* sp. in Fig. 60; 63, vagina (straight) of *S.* sp.; 64, microfilaria of *S.* sp. in Fig. 63.

Fig. 65. Microfilaria of *Chandlerella robinsoni*.

cular portion of the esophagus expanded into a distinct bulb-like enlargement (Figs. 7, 8).

C. chitwoodae (Fig. 37) and *C. petrowi* (Fig. 45) have spicules that are slender and sickle-shaped and thereby differ distinctly from *C. robinsoni* (Figs. 5, 6) and *C. skrjabini* (Fig. 50).

C. robinsoni has spicules that are definitely pointed, no pre-, no peri-, but five pairs of postanal papillae and a tail 154-231 long (Fig. 5). It thereby differs markedly from *C. skrjabini* with spicules somewhat truncated (Fig. 50), one pair pre-, one pair peri-, and two pairs of postanal papillae, and a tail 73 long.

Key to species of males of *Chandlerella*¹

- 1. Cuticle with bosses; esophagus not visibly divided; spicules broad, right with tip pointed, 60 long, left bluntly rounded, 50 long, one pair postanal papillae at tip of tail (Fig. 55) *C. travassosi* (Koroliowa, 1926)
- Cuticle without bosses, esophagus visibly divided into muscular and glandular parts 2
- 2(1). Anterior end of muscular portion of esophagus expanded into distinct bulbar structure 3
- Anterior end of muscular part of esophagus not bulbar 6
- 3(2). Spicules sickle-shaped 4
- Spicules not sickle-shaped 5
- 4(3). Both spicules narrow throughout entire length, right 126 long, left 90 long, one pair pre- and seven pairs postanal papillae; tail 68 long (Fig. 45) *C. petrowi* (Tschertkow, 1946)
- Left spicule with tip expanded ventrally, 67-90 long, right narrow distally, 67-128 long; four postanal papillae on one side and five on other side; tail 57-68 long (Fig. 37) *C. chitwoodae* Anderson, 1961
- 5(3). Spicules somewhat truncated distally, right thickened medially, 68 long, left fairly uniform in width, 86 long; tail 73 long; one pair peri- and two pairs postanal papillae; tail 73 long (Fig. 50) *C. skrjabini* (Petrov and Tschertkow, 1947)
- Spicules definitely pointed, somewhat similar in shape, right 75-90 long, left 55-75 long; no pre-, no peri-, but five pairs postanal papillae; tail 154-231 long (Figs. 5-9) *C. robinsoni* n. sp.
- 6(2). One or both spicules partially or distinctly truncated distally, sometimes notched or split distally 7
- Neither spicule truncated, notched, or split distally, but pointed or rounded 10
- 7(6). Both spicules distinctly truncated, right 59-62 long, body about equal in width, left 68-70 long, large median and smaller distal portions expanded ventrally; four pairs postanal papillae; tail 174-178 long (Fig. 38) *C. columbae* Sonin, 1966
- Only one spicule truncated, notched, or split distally 8
- 8(7). Left spicule truncated, 70 long, right with point set off by constriction, 80 long; four pairs postanal papillae; tail 160 long (Fig. 34) *C. apusi* Sonin, 1963
- One spicule notched or split distally 9
- 9(8). Left spicule straight, split distally, divided transversally into about equal anterior and posterior parts, 71 long, right with

¹Two species listed by Anderson and Freeman (1969) are not included in the key due to inadequate descriptions and the absence of figures. *C. lienalis* (Orloff, 1947) from grouse has pointed spicules, the right 150 long and the left 155; five pairs of postanal papillae; tail 120 long. *C. shaldybini* (Gubanov, 1954) from cormorants has spicules that are 84 long, divided into two parts and grooved; three pairs of preanal papillae; tail 84 long.

- rounded tip, body thick, 62 long; one pair pre- and seven pairs postanal papillae; tail 79 long (Fig. 44) *C. periarterialis* (Cabellero, 1948)
- Left spicule with distinct notch in tip, bent sharply at about distal third, broad basally, 72-81 long; right with median third thickened, tip rounded, 62-70 long, four pairs postanal papillae; tail 240 long (Fig. 33) *C. alii* Sultana, 1962
- 10(6). Body 25 mm or more long; left spicule bent sharply ventrad distally .. 11
 Body 20 mm or less in length; no preanal papillae (*C. bosei* [couplet 21] 9-11 mm long) 12
- 11(10). Spicules pointed, right 73-84 long, thinner than left, left 91-94 long; four pairs pre- and three pairs postanal papillae; tail 70-90 long (Fig. 36) *C. braziliensis* Yeh, 1957
 Spicules robust, about equal in width throughout length, heavily chitinized on dorsal side, right 64-95 long, left 75-105 long; three to four pairs postanal papillae; tail 200-270 long (Fig. 46) *C. quisquali* (von Linstow, 1904)
- 12(10). Body less than 10 mm long 13
 Body 10 mm or more long 14
- 13(12). Spicules pointed, sickle-shaped, both transversally striated throughout length, right with distal third thicker, 80-97 long, left slender, 58-68 long, five pairs postanal papillae; body 4-7 mm long; tail 61 long (Fig. 52) *C. striatospiculata* Hibler, 1964
 Spicules smooth, robust, neither sickle-shaped nor acute distally, right 60, left 72; three pairs postanal papillae; body 6 mm long; tail 153 long (Fig. 54) *C. thapari* Rasheed, 1960
- 14(12). Spicules distinctly acute distally 15
 Spicules rounded distally 16
- 15(14). Spicules narrow throughout length, right 119 long, left 78 long, caudal papillae uncertain⁵; tail 80 long (Fig. 51) *C. stantchinskyi* Gilbert, 1932
 Right spicule greatly thickened medially, 70-80 long, left not thickened medially, 70-80 long; four pairs postanal papillae; tail 240 long (Fig. 39) *C. columbigallinae* (Augustine, 1937)
- 16(14). Tail 325-345 long; right spicule 56-59 long, left spicule 74-76 long; three pairs postanal papillae (Fig. 43) *C. longicaudata* Sonin, 1966
 Tail not exceeding 300 long 17
- 17(16). Tip of each spicule broadly rounded 18
 Tip of at least one spicule somewhat pointed but not acute 19
- 18(17). Right spicule with prominent ventral toothlike projection in basal third, middle third widest, 60-62 long, left spicule more robust, divided into three parts, without toothlike projection, 69-71 long; three pairs postanal papillae; tail 270-300 long (Fig. 49) *C. singhi* Ali, 1956
 Spicules without toothlike projections, left the more strongly bent, 79 long, right narrower, straighter, 72 long; four pairs postanal papillae; tail 300 long (Fig. 53) *C. sultana* Sonin, 1966
- 19(17). Right spicule with prominent midventral toothlike projection, the more slender, 50-60 long, left much broader, with ventral indentation separating two bulges; three pairs postanal papil-

⁵Sultana (1962) reported four pairs of postanal papillae; right spicule 72 long, left 79; no illustrations.

lae; tail 200-230 long (Fig. 48) *C. sinensis* Li, 1933
 Spicules without toothlike projection 20

20(19). Spicules with longitudinal grooves 21
 Spicules without grooves 22

21(20). Grooves on ventral side, right spicule with blunt tip, left pointed and bent, sharply ventrad, both 70-90 long; three pairs postanal papillae; tail 140-160 long (Fig. 35)
 *C. bosei* (Chandler, 1924)
 Grooves on dorsal side, giving spicules bipartite appearance, right 85-126 long, left 67-95 long; four pairs postanal papillae; tail 70-105 long (Fig. 40) *C. flexivaginalis* (Jones, 1961)

22(20). Spicules slender, right with obtuse angular bend on middorsal side, slightly expanded on mid ventral side, 90-100 long, left slender, sides nearly parallel, 80-90 long, three pairs postanal papillae; tail 190-210 long (Fig. 42) *C. himalayensis* Sultana, 1962
 Spicules robust, dissimilar, both broad except right, which has narrow necklike proximal part, each with elongated internal thickened chitinous portion; right 54-60 long, left 62-70 long; four to five pairs postanal papillae; tail 180-220 long (Fig. 41) *C. hawkingi* Chatterjee, Sen, and Bhattacharya, 1965

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